

CHAPTER 16: LYMPHATIC SYSTEM, NONSPECIFIC RESISTANCE, & IMMUNITY

OBJECTIVES:

1. Name the organs that compose the lymphatic system and give 3 general functions performed by this system.
2. Trace the flow of lymph from the interstitial tissues to the bloodstream.
3. Discuss the function of anchoring filaments that surround lymphatic capillaries.
4. Name four tissues that do not contain lymphatic capillaries.
5. Give the special name for lymphatic capillaries within the wall of the small intestine.
6. Distinguish between an afferent and efferent lymphatic vessel.
7. Explain how lymphatic vessels are similar to veins.
8. List the five primary body regions drained by a lymphatic trunk.
9. Name the two lymphatic collecting ducts and indicate the portion of the body drained by each.
10. Name the vein that each of the two collecting ducts deposit their lymph into.
11. Discuss the composition, function, and movement of lymph.
12. Explain what happens when lymphatic flow is obstructed.
13. Discuss the structure, location, and function of a lymph node.
14. Discuss the structure, location, and function of the spleen.
15. Distinguish between the body fluids filtered by lymph nodes and those filtered by the spleen.
16. Name the cell responsible for the filtering action of the lymph node and spleen.
17. Discuss the structure, location, and function of the thymus.
18. Name the hormone secreted by the thymus that causes maturation of lymphocytes that

have migrated to other tissues.

19. Define the term *pathogen*.

CHAPTER 16: LYMPHATIC SYSTEM, NONSPECIFIC RESISTANCE, AND IMMUNITY

Objectives (continued)

20. Distinguish between the body's two types of defense mechanisms against infections.
21. Define the term *nonspecific resistance* and discuss the body's six major mechanisms.
22. Name the antibacterial enzyme present in tears.
23. List the cardinal signs of inflammation.
24. Define the term *specific immunity*.
25. Discuss the origin and maturation of lymphocytes.
26. Define the terms *antigen (Ag)*, *immune response (IR)*, and *haptens*.
27. Distinguish between a T-lymphocyte (T-cell) and B-lymphocyte (B-cell).
28. Distinguish between Cell-Mediated Immunity (CMI) and Antibody-Mediated Immunity (AMI).
29. List the many functions of lymphocytes, noting whether the action is CMI or AMI.
30. Discuss the general structure of an antibody (immunoglobulin [Ig]).
31. Name the five major classes of immunoglobulins and list the major characteristics of each.
32. Name the most abundant Ig.
33. Name the only Ig that can cross the placenta.
34. Name the Ig first produced during an IR.
35. Name the Ig released during allergic reactions.
36. Discuss the many actions of antibodies.

37. Distinguish between agglutination, precipitation, neutralization, and lysis.
38. Compare and contrast a primary IR vs. a secondary IR.
39. Discuss the four types of specific immunity.
40. Explain the different types of allergic reactions.

CHAPTER 16: LYMPHATIC SYSTEM, NONSPECIFIC RESISTANCE, AND IMMUNITY

I. Introduction

The lymphatic system is closely associated with the cardiovascular system. The primary organs of the lymphatic system are the bone marrow and thymus gland, and the secondary lymphatic organs include the lymph nodes and spleen. These organs work together to transport excess tissue (interstitial) fluid to the blood stream, transport dietary fat, and help defend the body against disease-causing agents.

Lymphatic tissue is a specialized reticular connective tissue that contains many lymphocytes.

II. Lymphatic Pathways

Lymphatic pathways begin as **lymphatic capillaries** which come together to form **afferent lymphatic vessels**, which lead to *lymph nodes*. The vessels that then leave the lymph nodes are called **effluent lymphatic vessels** which come together to form **lymphatic trunks**, which lead to **two collecting ducts** which finally join the **subclavian veins**, where the lymph enters the cardiovascular system.

See General Overview Figure 16.1, page 622 and Fig 16.7, page 625.

A. Lymphatic capillaries:

See Fig 16.2, page 622 and Fig 16.8, page 639.

1. are microscopic closed-ended tubes that extend into interstitial spaces;
2. receive lymph through their thin walls;
3. are associated with **anchoring filaments**, which serve an important function during edema (discussed later);
4. are located throughout the body, except in:
 - a. avascular tissues;
 - b. CNS;
 - c. splenic pulp;
 - d. bone marrow.

5. include **lacteals** that are lymphatic capillaries within villi of the small intestine.

CHAPTER 16: LYMPHATIC SYSTEM, NONSPECIFIC RESISTANCE, AND IMMUNITY

II. Lymphatic Pathways (continued)

B. **Lymphatic vessels:** See Fig 16.3 -16.5, page 623.

1. are formed by the merging of lymphatic capillaries;
2. have walls similar to veins and possess **valves** that prevent backflow of lymph;
3. lead to lymph nodes as "afferent" LVs, leave lymph nodes as "efferent" LVs, and then merge into lymphatic trunks.

C. **Lymphatic trunks:**

See Fig 16.4, page 623.

1. drain lymph from relatively large body regions;
2. Principal lymphatic trunks are the:
 - a. lumbar;
 - b. intestinal;
 - c. bronchomediastinal;
 - d. subclavian;
 - e. jugular;
 6. intercostal.
3. pass their lymph into venous blood by joining one of two collecting ducts.

D. **Collecting ducts:** See Fig 16.6, page 624.

1. Two within the thoracic cavity;
 - a. **right lymphatic duct** drains the right upper body (25% of total body);
 - b. **thoracic (left lymphatic) duct** drains the remaining 75% of the body's lymph;
2. join the **subclavian veins**.

- * See the above figures to study the relationship of lymphatic system to CV system.

CHAPTER 16: LYMPHATIC SYSTEM, NONSPECIFIC RESISTANCE, AND IMMUNITY

III. Lymph

A. Composition

1. interstitial fluid (i.e. plasma minus proteins);

B. Functions of lymph

1. returns leaked plasma proteins back to the blood stream;
2. **transports foreign particles to the lymph nodes;**
3. transports lipids and lipid-soluble vitamins absorbed in GI tract to blood stream.

C. Movement of Lymph

1. Flow of lymph

- a. Lymph is under low pressure and may not flow readily without aid from external forces:
 - the squeezing action of skeletal muscles;
 - low pressure in the thoracic cavity created by breathing movements moves lymph up from abdominal to thoracic region;
 - recall the presence of one-way valves.

2. Obstruction of lymph movement

- a. Any condition that interferes with the flow of lymph results in **edema**.
- b. Edema = accumulation of excess interstitial fluid leading to swelling of tissues;

- c. Tissue swelling pulls on **anchoring filaments** making openings between cells even larger so that more fluid can move into the lymphatic capillary (i.e. reducing swelling). See Fig 16.8, page 625.

CHAPTER 16: LYMPHATIC SYSTEM, NONSPECIFIC RESISTANCE, AND IMMUNITY

IV. Lymphatic Tissues

A. Introduction

Lymphatic tissue occurs in the body in various ways.

1. When it is not encapsulated, it is called **diffuse lymphatic tissue** (i.e. found in submucosa of mucous lining).
2. When it is aggregated into a solitary, oval-shaped mass, it is called a **lymphatic nodule** (i.e. tonsils, and recall the lymphatic nodule in the small intestine model).
3. Primary lymphatic organs are the sites of production of immunocompetent cells, B cells and T cells. These cells can carry out an immune response.
 - a. bone marrow (red);
 - b. thymus.
4. Secondary lymphatic organs are the sites where most immune responses occur.
 - a. lymph nodes;
 - b. spleen.

B. Lymph Nodes

1. **Structure** of a lymph node (See Fig 16.9, page 626.)
 - a. bean shaped with blood vessels, nerves, and **efferent lymphatic vessels** attached to the indented region (**hilus**);
 - **Afferent lymphatic vessels** enter at points on the convex surface.
 - b. enclosed in a dense CT **capsule** that extends into the node and subdivides it into nodules.
 - c. Outer region = **cortex**; contains densely packed **B cells** (+ macrophages) called **follicles** (i.e. lymphatic nodule);
 - d. Inner region = **medulla**; contains T cells (+ macrophages and

plasma cells) arranged as **medullary cords**.

CHAPTER 16: LYMPHATIC SYSTEM, NONSPECIFIC RESISTANCE, AND IMMUNITY

IV. B. Lymph Nodes (continued)

2. **Flow of Lymph** through Lymph Node

- a. one-way direction only;
- b. Lymph enters the node through one of several afferent lymphatic vessels on convex surface,
- c. flows inward through sinuses (between medullary cords), and
- d. exits the node via one of two efferent lymphatic vessels at the hilus.

3. **Locations** of lymph nodes (See Fig 16.11, page 627.)

- a. Lymph nodes generally occur in groups or chains along the paths of larger lymphatic vessels.
- b. They occur primarily in the following regions:
 - **cervical,**
 - **axillary,**
 - **iliac,**
 - **inguinal.**
- c. They also occur within the following body cavities:
 - pelvic,
 - abdominal,
 - thoracic.

4. **Functions** of lymph nodes

- a. Lymph nodes are **centers for the production of lymphocytes** that act against foreign particles.

- b. They contain **macrophages** that remove and destroy foreign particles from lymph.

CHAPTER 16: LYMPHATIC SYSTEM, NONSPECIFIC RESISTANCE, AND IMMUNITY

IV. Lymphatic Tissues/Organs (continued)

C. **Thymus** (See Fig 16.12 page 628)

1. soft, bilobed organ located within the mediastinum;
2. decreases in size after puberty;
3. composed of lymphatic tissue that is subdivided into lobules;
4. Each lobule contains an outer (dark-staining) **cortex** filled with densely packed lymphocytes around a central **medulla** (light staining) filled with swirled epithelial cells (called Hassall's Corpucles); See Fig 16.13, page 629.
5. Functions:
 - a. immature T cells migrate from the bone marrow to the thymus (via) the blood.
 - **The thymus is the site of maturation of T cells.**
 - b. The epithelial cells secrete a hormone called **thymosin** which stimulates the maturation of T cells that have migrated to other lymphatic tissues.

D. **Spleen** (See Figure 16.14 page 629)

1. is located in the upper left portion of the abdominal cavity (behind stomach).
2. resembles a large lymph node that is encapsulated and subdivided into lobules by connective tissue.
3. contains two types of tissue: See Fig 16.15, page 629.
 - a. **white pulp** = lymphocytes arranged around central arteries;
 - b. **red pulp** = venous sinuses (filled with blood; serves as blood reservoir) and splenic (Billroth's) cords;
4. functions
 - a. **phagocytosis of bacteria and removal of damaged or worn red blood cells and platelets from the blood** (main function);
 - b. stores and releases blood during hemorrhage.
 - c. in immunity as a site of B cell proliferation into plasma cells.

* See summary Table 16.1, page 630 on major lymphatic organs.

CHAPTER 16: LYMPHATIC SYSTEM, NONSPECIFIC RESISTANCE, AND IMMUNITY

V. Body Defenses against Infection

A. Introduction

Infection is caused by the presence and multiplication of pathogens. **Pathogens are viruses and microorganisms** (bacteria, fungi, protozoans, parasites) **that cause disease.**

The body is equipped with two types of defense mechanisms to fight infection; these include **nonspecific resistance** and **specific immunity.**

B. **Nonspecific Resistance** = protection against a wide range of pathogens. Mechanisms include species resistance, mechanical barriers, enzymes, interferon, inflammation and phagocytosis.

1. Species resistance

Each species of organism is resistant to certain diseases that may affect other species, but susceptible to diseases that other species may be able to resist. (See cryptosporidiosis, page 630).

2. Mechanical barriers

- a. include the **skin and mucous membranes**;
- b. As long as mechanical barriers remain unbroken, they prevent the entrance of some pathogens.

3. Enzymatic actions

- a. The enzyme in **gastric juice** (i.e pepsin) is lethal to many pathogens;
- b. The enzyme in **tears** (i.e lysozyme) has antibacterial action.

4. Interferon

- a. Interferon is a group of hormone-like peptides produced by certain cells in response to the presence of viruses.

- b. It can **interfere with the proliferation of viruses**, stimulate phagocytosis, and enhance the activity of cells that help resist infections and the growth of tumors.

CHAPTER 16: LYMPHATIC SYSTEM, NONSPECIFIC RESISTANCE, AND IMMUNITY

V. A. Nonspecific Resistance (continued)

5. **Phagocytosis**

- a. The most active phagocytes in the blood are **neutrophils and monocytes**; monocytes give rise to macrophages that remain fixed in tissues.
- b. Phagocytic cells associated with the linings of blood vessels in the bone marrow, liver, spleen, and lymph nodes constitute the reticuloendothelial tissue.
- c. Phagocytes remove and destroy foreign particles from tissues and body fluids.

6. **Inflammation**

See Table 16.2, page 631.

- a. Inflammation is a tissue response to damage, injury, or infection.
- b. The response includes localized **redness (rubor), swelling (tumor), heat (calor), and pain (dolor)**.
- c. Chemicals released by damaged tissues attract various white blood cells to the site of inflammation.
- d. Clotting may occur in body fluids that accumulate in affected tissues.
- e. Fibrous connective tissue may form a sac around the injured tissue and thus prevent the spread of pathogens.

* See Summary Chart 16.3 page 632 to review nonspecific resistance mechanisms.

CHAPTER 16: LYMPHATIC SYSTEM, NONSPECIFIC RESISTANCE, AND IMMUNITY

V. Body Defense Mechanisms (continued)

B. **Specific Immunity** = protection against **particular** disease-causing agents.

1. **Origin of lymphocytes**

See Fig 16.16, page 633.

- a. **Lymphocytes originate in red bone marrow** and are released into the blood before they become differentiated.
- b. Some reach the **thymus where they become T cells**.
- c. Those failing to reach the thymus become **B cells** after being processed in some other region of the body.
- d. Both T and B cells tend to reside in organs of the lymphatic system.

2. **Antigens**

- a. Before birth, cells make an inventory of the proteins and other large molecules present in the body.
- b. After the inventory, lymphocytes develop receptors that allow them to differentiate between foreign substances and self-substances.
- c. **Antigens (Ag's) are foreign substances that** combine with T-cell and B-cell surface receptors, and stimulate these cells to **cause an immune response (IR)**.
- d. Some small Ag's cannot produce an IR on their own. These small Ag's or **haptens** can combine with a larger ones however, forming combinations which can produce an IR.

CHAPTER 16: LYMPHATIC SYSTEM, NONSPECIFIC RESISTANCE, AND IMMUNITY

V. B. Specific Immunity (continued)

3. Functions of lymphocytes

a. T cells provide cell-mediated immunity (CMI):

Cytotoxic T cells interact with antigen-bearing agents directly, providing cell-mediated immunity (**CMI**).

- T cells secrete **lymphokines**, such as interleukins, that enhance many cellular responses to antigens.
- T cells may also secrete substances that are **toxic to their target cells**, prevent target cell growth (**growth inhibiting factors**), or prevent virus proliferation (**interferon**).

b. B cells provide Antibody-mediated immunity (AMI): (humoral)

- B cells interact with antigen-bearing agents **indirectly**, by secreting proteins called **antibodies**.

*See Table 16.5, page 637 to compare T and B cells.

4. Antibody molecules (AMI)

See Figure 16.20, page 637.

- a. Antibodies are proteins called **immunoglobulins**.
- b. They constitute the **gamma globulin** fraction of plasma.
- c. Each immunoglobulin molecule consists of four chains of amino acids linked together.
- d. Variable regions at the ends of these chains are specialized to react with antigens.

CHAPTER 16: LYMPHATIC SYSTEM, NONSPECIFIC RESISTANCE, AND IMMUNITY

V. B. Specific Immunity (continued)

5. Classes of immunoglobulins (AMI)

See Table 16.6, page 639.

The **five major types** of immunoglobulins are IgG, IgA, IgM, IgD, and IgE.

a. **IgG**

- most abundant (75% of total);
- monomer;
- produced against bacteria, viruses & toxins;
- only antibody to cross placenta.

b. **IgA**

- about 15% of antibodies;
- occur in exocrine fluids (tears, saliva);
- levels decrease during stress, lowering resistance to infection;

c. **IgM**

- about 5-10 % of antibodies;
- pentamers;
- first antibodies to be secreted after initial exposure to an antigen;
- in plasma;
- produced in blood transfusions.

d. **IgD**

- < 1% of antibodies;
- monomers;
- involved in activation of B-cells.

e. **IgE**

- < 0.1 % of antibodies;

- monomers;
- located on eosinophils and basophils;
- involved in allergic reactions because they cause the release of histamine from the above cells.

CHAPTER 16: LYMPHATIC SYSTEM, NONSPECIFIC RESISTANCE, AND IMMUNITY

V. B. Specific Immunity (continued)

6. **Actions of antibodies (AMI):**

See Table 16.7, page 640.

a. Antibodies **attack antigens directly**,

- agglutination,
- precipitation,
- neutralization,

b. Antibodies **activate complement (positive feedback mechanism)**

- opsonization,
- chemotaxis,
- inflammation,
- lysis.

7. **Immune responses:** See Fig 16.23, page 641.

a. When B cells or T cells first encounter an antigen for which they are specialized to react, the reaction is called a primary immune response.

- During this response, antibodies are produced for several weeks (IgM)
- Some B cells and T cells remain dormant as memory cells .

b. A secondary immune response occurs rapidly if the same antigen is encountered later (IgG).

8. **Types of specific immunity** (See Table 16.8, page 643)

a. A person who encounters a pathogen and has a primary immune

- response develops **naturally acquired active immunity**.
- b. A person who receives vaccine containing a dead or weakened pathogen develops **artificially acquired active immunity**.
 - c. A person who receives an injection of gamma globulin that contains ready-made antibodies has **artificially acquired passive immunity**.
 - d. When antibodies pass through a placental membrane from a pregnant woman to her fetus, the fetus develops **naturally acquired passive immunity**.

CHAPTER 16: LYMPHATIC SYSTEM, NONSPECIFIC RESISTANCE, AND IMMUNITY

VI. Disorders/homeostatic Imbalances of the Immune System

A. **Allergic reactions** (IR gone awry)

1. Allergic reactions involve antigens combining with antibodies (IgE); such reactions are likely to be excessive or violent and may cause tissue damage.
2. **Delayed-reaction allergy**, which can occur in anyone and can cause inflammation of the skin, results from repeated exposure to antigenic substances (i.e household detergents, cosmetics).
3. A person with **immediate-reaction allergy** has an inherited ability to produce an abnormally large amount of IgE (animal dander, pollen, etc.).
4. Allergic reactions may damage eosinophils and basophils, which in turn release **histamine and serotonin**.
5. Released chemicals are responsible for the **symptoms of the allergic reaction: hives, hay fever, asthma, eczema, or gastric disturbances**.
6. An allergic reaction is usually terminated by suppressor cells that inhibit the production of IgE.

B. Transplantation and Tissue Rejection (See intro on page 621 & page 644)

C. Autoimmune Disorders (See Chart 16.10, page 647)

4. Severe Combined Immune Deficiency (page 642)
5. Chronic Fatigue Syndrome (page 646)
6. AIDS (See CA 16.2, page 648-649)

VII. Other Interesting Topics Concerning the Lymphatic System:

A. Immunotherapy (See CA 16.1, page 638-639)

B. Vaccines (page 642)

C. Tuberculin Skin Test (page 643)

D. Major Histocompatibility Complex (MHC): page 644.

VIII. Innerconnections of the Lymphatic System: See page 650.

